Final Project Report to the NYS IPM Program, Agricultural IPM 2000 – 2001

Title:
Evaluating New Nozzles and an Air Assist Sprayer for Improving Spray Coverage and Powdery Mildew Control on Underleaf Surfaces

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Type of grant:
Pheromones; biorationals; microbials; conventional pesticides

Project location(s):
Suffolk County

Abstract:
The goals of this project were to identify equipment that maximizes spray coverage on the underside of leaves of cucurbits and to determine if powdery mildew can be controlled effectively with nonsystemic fungicides when coverage is maximized. Conventional nozzles and sprayers deliver little spray material to the underside of leaves. Thus systemic fungicides are currently essential for controlling powdery mildew in cucurbits. Fungicide resistance is a major concern because systemic fungicides are at-risk for resistance development due to their single-site mode of action and because the powdery mildew fungus has demonstrated high potential for developing resistance. Organic growers would also benefit from identification of a means to improve spray deposition as there are no systemic fungicides approved for organic production. The contact fungicide Bravo was applied using an air assist sprayer and using two novel nozzles (twin jet and air induction) and three traditional nozzles (flat fan, hollow cone, and cone jet) on a conventional boom. Parallel experiments were conducted on muskmelon and on pumpkin because these cucurbit crops have different canopies.

Neither the air assist boom nor the novel nozzles improved control achieved with Bravo applied with conventional nozzles on a hydraulic boom. Control was improved on the lower leaf surface only when systemic fungicides were also used. This study has demonstrated that it is challenging to improve spray coverage on the lower surface of muskmelon and pumpkin leaves by changing spray equipment. This may be due to their large size. However, results from one year of research cannot be considered conclusive. Considering the potential great benefit of

improved spray coverage on cucurbit crops, additional research on novel nozzles and air assist application technologies is warranted. Perhaps these nozzles will be more effective used at different pressure or gallonage. If coverage can be improved sufficiently, growers will be able to reduce the quantity of pesticides used because they will not need to apply systemic fungicides as much as they now need to. Implementing the necessary changes to achieve better spray coverage will not be very costly if the novel nozzle types for a conventional boom can provide better coverage than traditional nozzle types. On the other hand, perhaps it will only be possible to achieve better coverage with novel spray application technologies on crops with smaller leaves, such as tomato.

Background and justification:

Effective control of powdery mildew in a cucurbit crop necessitates controlling the disease on the underside of leaves. Conditions are more favorable for development of powdery mildew on the under compared to upper surface. A protectant fungicide applied with conventional nozzles is deposited almost exclusively on the upper surface of leaves. Leaves die prematurely when powdery mildew is not controlled effectively on the underside. Thus systemic fungicides have been critically important for powdery mildew control. Unfortunately, systemic fungicides are at-risk for resistance development. The powdery mildew fungus has demonstrated high potential for developing resistance.

A means to improve spray deposition on the leaf underside would reduce grower dependence on systemic fungicides. It would also improve resistance management by increasing the proportion of the pathogen population exposed to the low-resistance-risk contact fungicide used in programs with systemic fungicides. It would be even more valuable for organic growers because there are no systemic fungicides that are approved for organic production.

New nozzles for conventional spray booms reportedly improve coverage by delivering more spray to the leaf underside and also by reducing drift. Twin-jet nozzles use forward and rearward pointing flat fans, thus providing two chances to hit the plant. They apply the same total amount of liquid as a conventional flat fan but halve the quantity for each hole, resulting in a small hole producing smaller droplets for a given output. Air induction (air inclusion or venturi) nozzles are flat fan nozzles where an internal venturi creates negative pressure inside the nozzle body. Air is drawn in through two holes in the nozzle side, mixing with the spray liquid. The emitted spray contains large (300 micron) droplets filled with air bubbles and virtually no fine, drift-prone droplets. Normally droplets this large would bounce off their target. However, because of the air they explode on impact and spread over the leaf as the air absorbs the impact load. Coverage is similar to that of finer sprays produced by traditional nozzles.

Another approach to improving coverage is to use an air assist sprayer. Air assist sprayers use air as a carrier for the pesticide. A fan is used that moves air at a fast speed thereby pushing the spray into the canopy and also generating turbulence that moves spray to undersides of leaves. Nozzle velocity can be up to 180 mph. This is an expensive means to improving coverage because it entails purchasing a new sprayer rather than just new nozzles. Another benefit of improved deposition is the potential to maintain good control but with lower pesticide rates.

The goals of this project were to identify spray equipment that maximizes spray coverage on the underside of leaves and to determine if powdery mildew can be controlled effectively with nonsystemic fungicides when coverage is maximized. Disease control is the ultimate measure of coverage because it includes the entire canopy, in contrast with water sensitive paper that can only measure a small percentage of the canopy. The sprayer used in this study is a tractor-drawn unit equipped with an air assist boom and a separate hydraulic boom set-up with multiple nozzles on a single nozzle body. Two novel nozzles (twin jet and air induction) were compared to 3 traditional nozzles (flat fan, hollow cone, and cone jet). All are considered ideal for applying fungicides. Flat fan 110 degree nozzles were chosen for their finer droplet characteristics compared to 80 degree nozzles. The hollow cone is a very traditional design comprising a core that creates the swirl (also called a swirl plate) and a ceramic disc that contains the hole. Cone jet nozzles create small droplets in an 80 degree cone. Parallel experiments were conducted on muskmelon and on pumpkin. These two cucurbit crops were selected because they have different canopies. Muskmelon leaves are much smaller and shorter than pumpkin leaves. Also, most leaves in the muskmelon canopy are at the same level whereas the pumpkin canopy consists of a few layers of leaves. Fungicide applications were made at the same time.

Objectives:

Compare different nozzle types for a conventional sprayer and an air assist sprayer in terms of spray coverage and powdery mildew control.

Procedures:

Transplants were seeded in the greenhouse on 17 May. Seedlings were transplanted on 19 June into black plastic mulch with drip irrigation. Plots contained 12 plants in three 4-plant rows. A randomized complete block design with four replications was used. There were two parallel experiments with pumpkin and muskmelon.

The contact fungicide Bravo Ultrex (2.7 lb/A) was applied with each nozzle on 1, 8, 16, and 23 Aug and 2 Sept. The pressure and gallonage used for each nozzle is listed in Tables 1 and 2. These were selected to be as similar as possible among the nozzles on the conventional boom. Gallonage was lower for the air assist spray because it uses air rather than water as the spray carrier. An additional treatment was the currently recommended fungicide program for cucurbit powdery mildew, Quadris (15.4 oz/A) applied in alternation with Bravo + Nova (5 oz/A) using the flat fan nozzles. This treatment was included to determine if a sufficient amount of Bravo could be deposited on low leaf surfaces with any of the nozzles tested to achieve a similar level of control as that obtained with the systemic fungicides Quadris and Nova. Both experiments were sprayed at the same time.

Powdery mildew severity on upper and lower (under) surfaces of 5 to 50 leaves in each plot was determined on 31 Jul; 7, 15, 22, and 28 Aug; and 6 Sept. Initially, 50 older leaves were examined in each plot. As disease progressed, leaves of other age classes (mid-aged and young) and fewer total leaves were examined. AUDPC, a cumulative measure of disease severity, was calculated for each leaf surface. The higher the AUDPC value the more severe the disease. Defoliation, predominantly due to powdery mildew, was assessed on 24 Aug and 4 Sep.

Spray coverage was also assessed by attaching water sensitive paper cards in pairs to both leaf surfaces for each nozzle type. Proportion of each card that changed color due to spray deposit was determined using a computer scanning program specifically designed for this purpose (Droplet Scan, WRK).

Ripe, rotten and green muskmelon fruit were counted on 4 and 11 Sep. Percentage of sucrose was determined using a hand refractometer for two ripe fruit per plot on 27 Aug and 4 Sept.

Results and discussion:

Neither the air assist boom nor the novel nozzles improved control of powdery mildew in muskmelon or pumpkin achieved with Bravo applied with conventional nozzles on a hydraulic boom. Control was improved on the lower leaf surface only when systemic fungicides were also used (Tables 1 and 2). The last application was delayed due to 2 days of windy conditions; however, it is unlikely this affected results.

Defoliation was significantly lower in fungicide-treated plots than nontreated plots on all assessment dates for muskmelon (Table 1). There were no significant differences among treatments on 24 Aug when defoliation was 1 to 5% versus 45% for nontreated. On 17 Sept, defoliation was lower for the Quadris alt Bravo + Nova treatment (21%) than for the Bravo treatments (42 to 61%). Nontreated fruit had the lowest sucrose concentration; however, there were no significant differences among treatments. Spray deposit on water sensitive paper corresponded to powdery mildew control results except that significantly less material was deposited on upper leaf surfaces with the air assist boom than with any nozzles on the hydraulic boom (Tables 1 and 2).

Table 1. Impact of sprayer, nozzle type, and fungicide program on powdery mildew severity in muskmelon, defoliation, and spray deposit.

Fungicide and rate/A [2]	Powdery mildew severity (% leaf coverage) [1]						Defol-iation	Spray deposit	
Sprayer type	upper leaf surface			lower leaf surface					
Nozzle (pressure, gallonage)	28 Aug	6 Sep	AUDPC	28 Aug	6 Sep	AUDPC	4 Sep	upper	lower
Nontreated …………………………………	69.52 a[3]	73.0 a	912 a	73 a	87 a	961 a	88 a		
Bravo 2.7 lb									
Hydraulic boom									
Flat fan (65 psi, 53 gpa) ………….……	0.06 b	3.5 b	18 b	49 b	61 bc	654 bc	21 bc	80 a	5
D3-45 hollow cone (65 psi, 76 gpa) …...	0.00 b	5.2 b	23 b	38 b	69 abc	601 c	9 bc	80 a	5
Conejet (80 psi, 42 gpa) ………………..	0.10 b	0.6 b	4 b	45 b	59 c	617 bc	13 bc	70 a	14
Twin-jet flat fan (65 psi, 68 gpa) ……...	0.34 b	3.5 b	21 b	40 b	65 abc	627 bc	20 bc	76 a	6
Air inclusion (72 psi, 74 gpa) ………….	0.17 b	2.1 b	15 b	53 b	83 ab	780 b	6 c	75 a	6
Air assist boom									
Yellow albuz (50 psi, 26 gpa) ……….....	0.38 b	11.4 b	58 b	36 b	60 bc	549 c	28 b	35 b	8
Quadris 15.4 oz alt Bravo + Nova 5 oz									
Hydraulic boom									
Flat fan (65 psi, 53 gpa) ………...………	0.00 b	0.2 b	1 b	2 b	49 c	239 d	9 bc		
P-value	0.0001	0.0001	0.0001	0.0001	0.0322	0.0001	0.0001	0.0016	0.571

[1] Powdery mildew colonies were counted and converted to severity using the conversion factor of 10 colonies/leaf = 1%. When colonies could not be counted accurately because they had coalesced and/or were too numerous, severity was estimated. Average severity for the entire canopy was calculated from the individual leaf assessments. A square root transformation was used when needed to stabilize variance. The table contains de-transformed values.

[2] Applications were made on 1, 8, 16, and 23 Aug and 2 Sept.

[3] Numbers in a column with a letter in common are not significantly different according to Fisher's Protected LSD ($P = 0.05$).

Table 2. Impact of sprayer, nozzle type, and fungicide program on powdery mildew severity in pumpkin, defoliation, and spray deposit.

Fungicide and rate/A [2]	Powdery mildew severity (% leaf coverage) [1]						Defol-iation	Spray deposit	
Sprayer type	upper leaf surface			lower leaf surface					
Nozzle (pressure, gallonage)	28 Aug	6 Sep	AUDPC	28 Aug	6 Sep	AUDPC	17 Sep	upper	lower
Nontreated …………………………..….	55.0 a[3]	61 a	899 a	73 a	84	1104 a	26 abcd		
Bravo 2.7 lb									
Hydraulic boom									
Flat fan (65 psi, 53 gpa) ……………..	0.4 b	9 b	51 b	63 a	80	975 a	31 abc	56 b	2
D3-45 hollow cone (65 psi, 76 gpa) …	1.9 b	3 b	29 b	74 a	68	968 a	16 cd	81 a	2
Conejet (80 psi, 42 gpa) ……………...	2.1 b	9 b	70 b	80 a	75	1099 a	23 abcd	77 a	2
Twin-jet flat fan (65 psi, 68 gpa) …….	1.0 b	6 b	34 b	75 a	88	1054 a	33 ab	70 ab	9
Air inclusion (72 psi, 74 gpa) ……….	0.7 b	9 b	49 b	66 a	87	1050 a	38 a	76 ab	1
Air assist boom									
Yellow albuz (50 psi, 26 gpa) ………..	2.6 b	3 b	40 b	74 a	73	989 a	18 bcd	27 c	4
Quadris 15.4 oz alt Bravo + Nova 5 oz									
Hydraulic boom									
Flat fan (65 psi, 53 gpa) ………...….	1.9 b	2 b	27 b	38 b	69	611 b	13 d		
P-value	0.0001	0.0001	0.0001	0.0044	0.3820	0.0005	0.0001	0.0001	0.588

1 Powdery mildew colonies were counted and converted to severity using the conversion factor of 10 colonies/leaf = 1%. When colonies could not be counted accurately because they had coalesced and/or were too numerous, severity was estimated. Average severity for the entire canopy was calculated from the individual leaf assessments. A square root transformation was used when needed to stabilize variance. The table contains de-transformed values.

2 Applications were made on 1, 8, 16, and 23 Aug and 2 Sep.

3 Numbers in a column with a letter in common are not significantly different according to Fisher's Protected LSD (P = 0.05).

Conclusions:

It was not apparent that the novel spray application technologies improved powdery mildew control with Bravo. This study has demonstrated that it is challenging to improve spray coverage on the lower surface of muskmelon and pumpkin leaves by changing spray equipment. This may be due to their large size. However, results from one year of research cannot be considered conclusive. Considering the potential great benefit of improved spray coverage on cucurbit crops, additional research on novel nozzles and air assist application technologies is warranted. Perhaps these nozzles will be more effective used at different pressure or gallonage. If coverage can be improved sufficiently, growers will be able to reduce the quantity of pesticides used because they will not need to apply systemic fungicides as much as they now need to. Implementing the necessary changes to achieve better spray coverage will not be very costly if the novel nozzle types for a conventional boom can provide better coverage than traditional nozzle types. On the other hand, perhaps it will only be possible to achieve better coverage with novel spray application technologies on crops with smaller leaves, such as tomato.